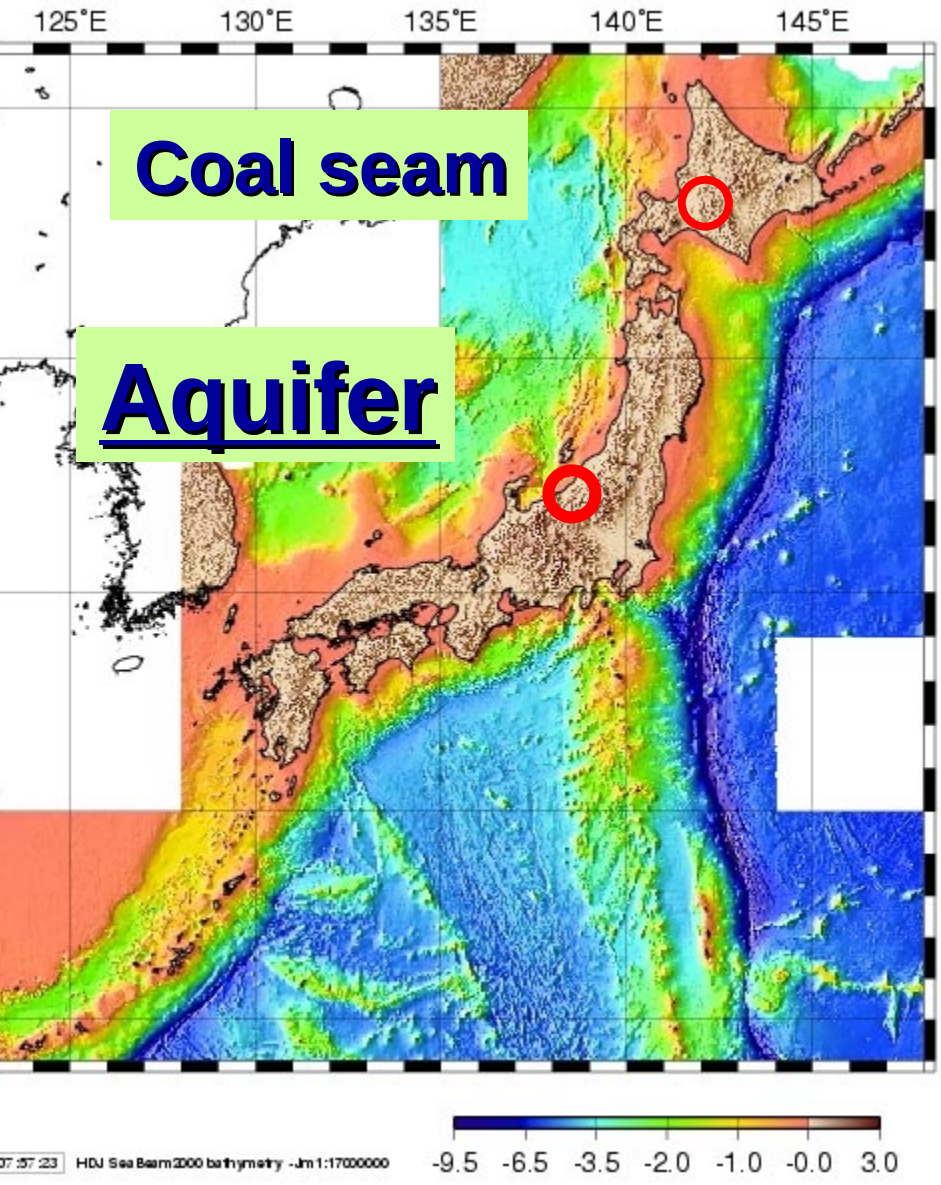
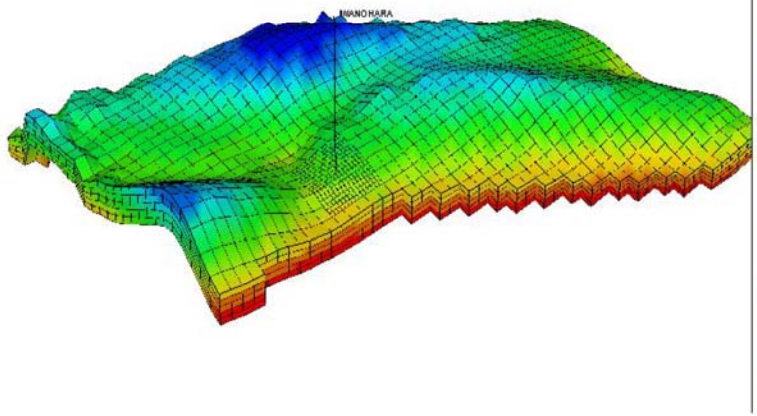


http://www1.kaiho.mlit.go.jp/KAIYO/sokuryo/nihonnsyuuhenn.html

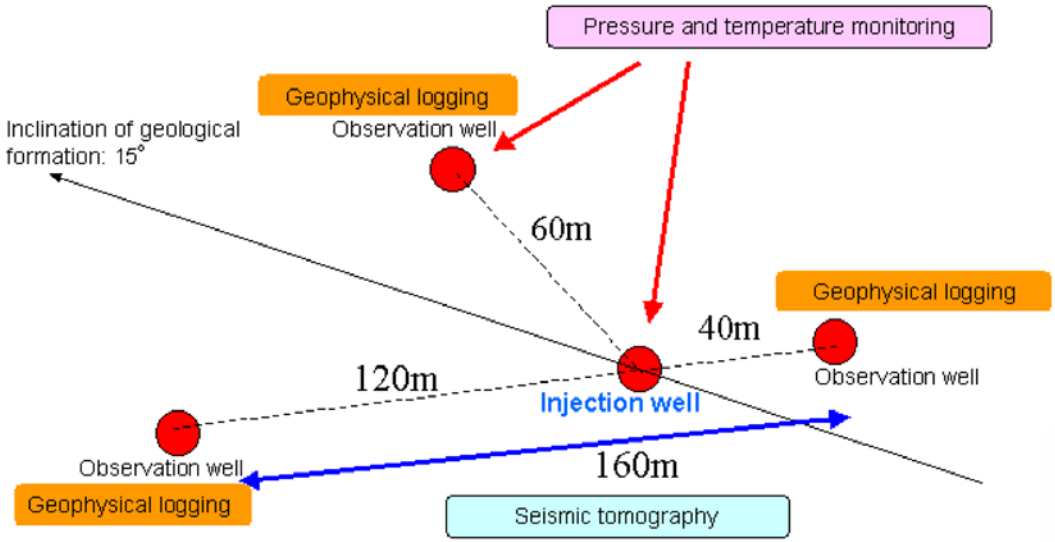
target aquifer

horizontal grid size:

- 25m × 25m in fine grid
- 50m × 50m / 200m × 200m in coarse grid

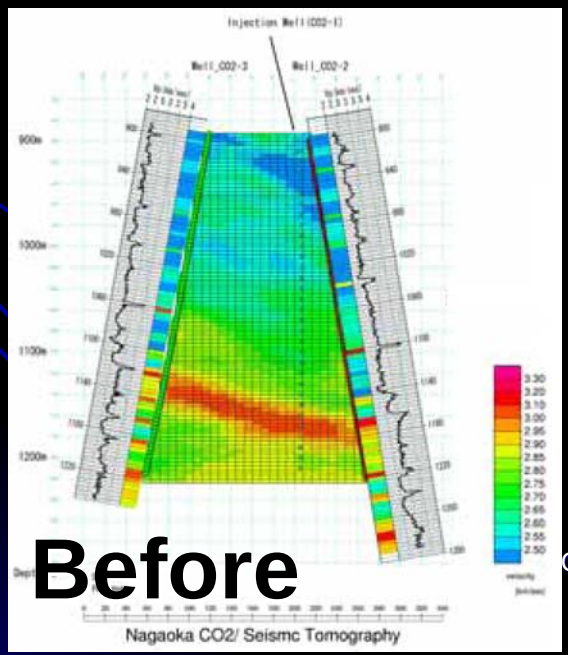


Cross-well tomography; velocity drop

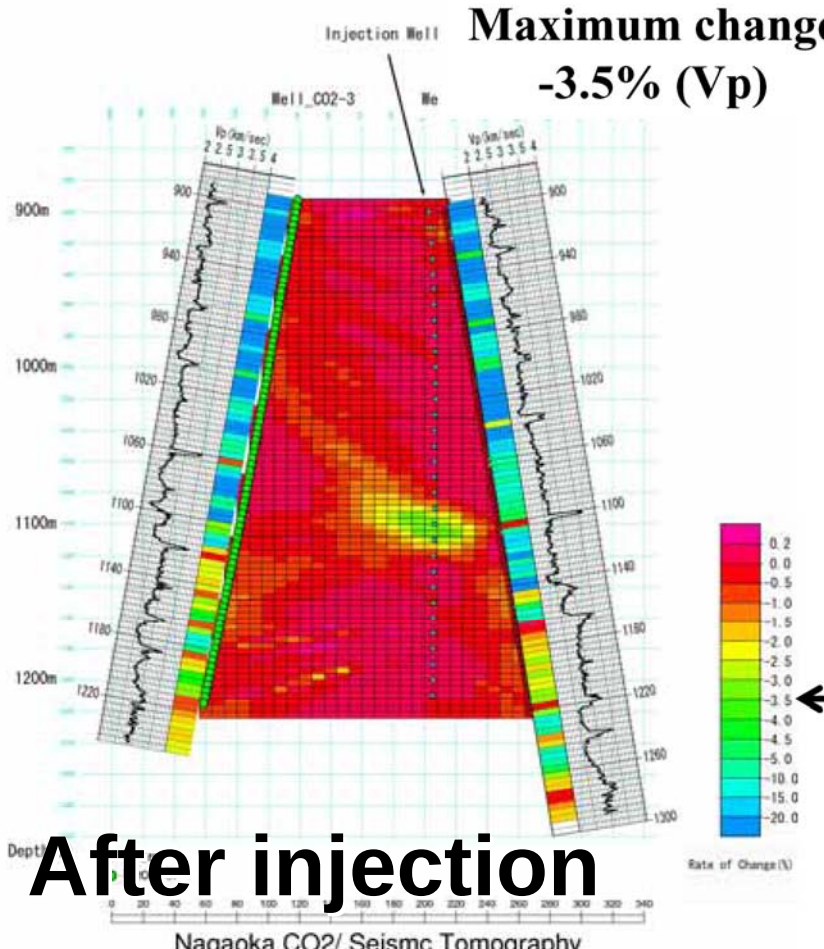


http://www.rite.or.jp/Japanese/project/tityu/press_j.html

http://www.rite.or.jp/Japanese/kicho/chosa/houkokukai/15kai/15kekka/osk3_choryu.pdf



Before



After injection

Alteration of formation barrier due to CO2 injection

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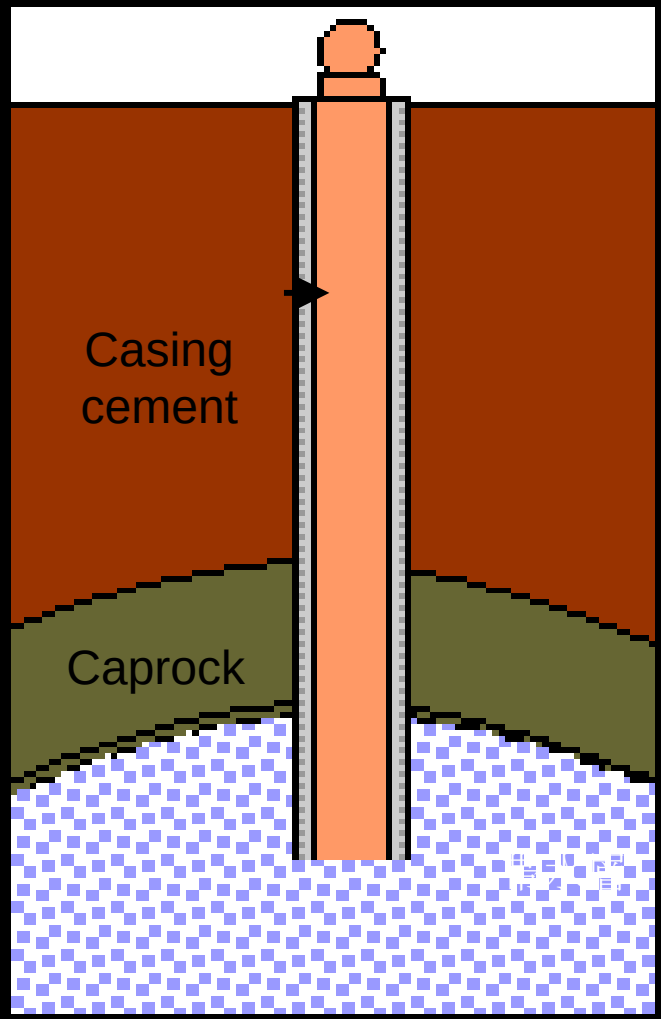
Daisuke TANAKA, Sumihiko MURATA

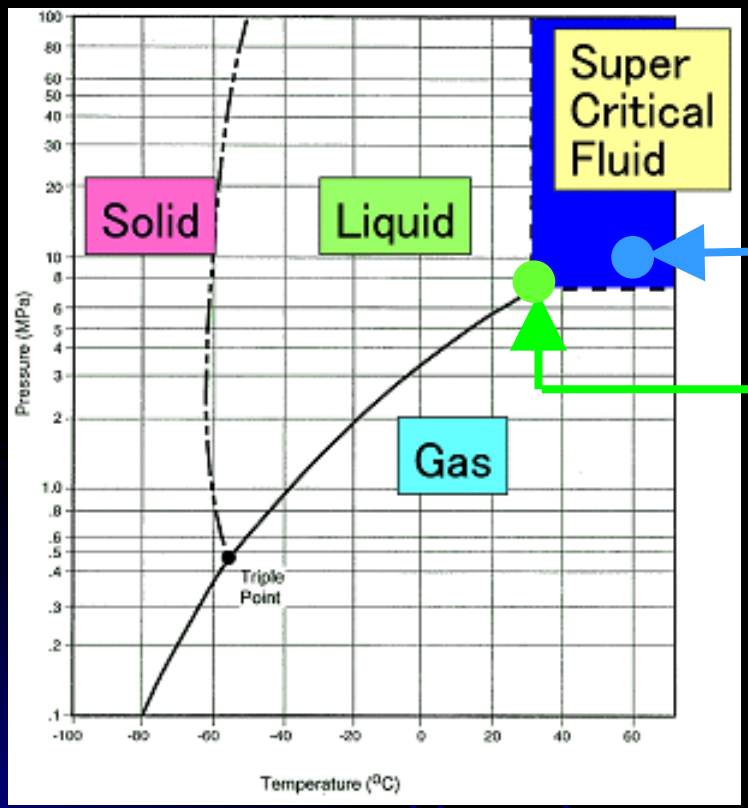
Earth Resources Engineering Department,
Kyoto University

Background of experiments

- Casing cement and cap-rock can be pathways of CO_2 leakage when altered by the injected gas.
- Long term exposure of such formation barrier against CO_2 needs to be investigated.



Underground condition of CO_2



Critical Point

Tc = 31.1℃

Pc = 7.39MPa

At the injection point

T = 60.0℃

P = 10.3MPa

CO_2 should be in a supercritical condition at the injection point (1000m deep).

Research Objective

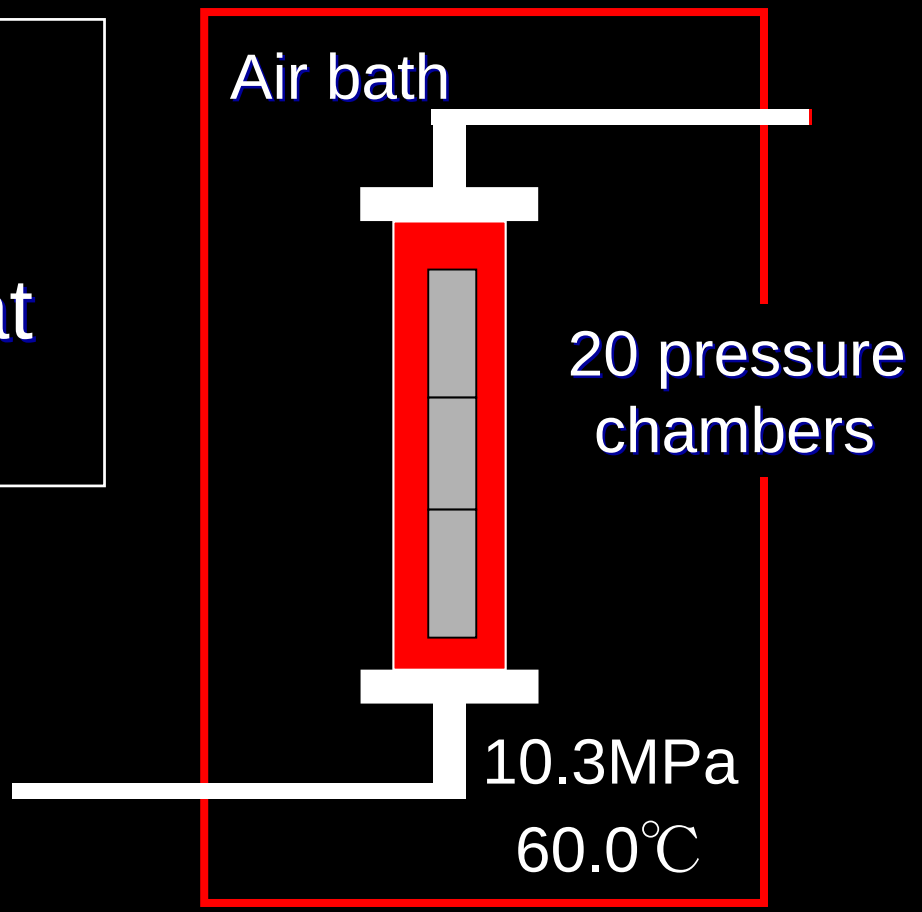
- To investigate the effects of supercritical CO_2 on the physical and geochemical properties of casing cement and cap-rock during a long term CO_2 exposure

The specimens & apparatus

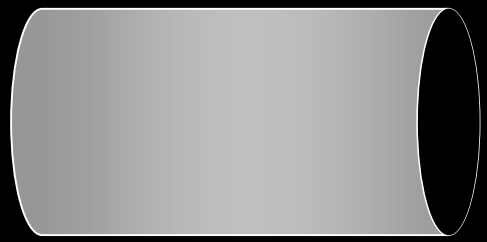
- Mudstones

  sampling from surface outcrops at cap-rock horizons

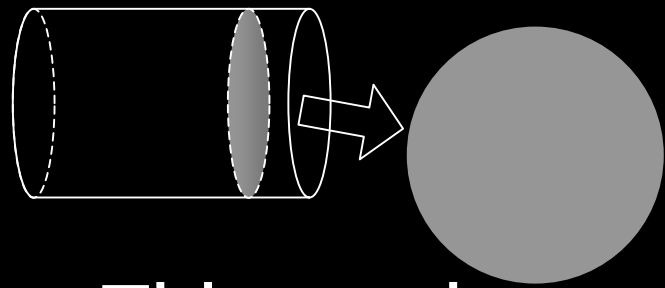
- Class-G cement
- CO_2 stop cement



Observation of specimens



Surface observation



Thin section

instruments

- microprobe
- SEM
- Polarization microscope

specimens

	durations
cements	3months
mudstones	2months

Results of Mudstones

	Ny-Mst	Al-Mst
0 mon		
1 mon	Colour change during 3 months of storage in artificial brain.	
2 mon		

No significant change after 1, 2 months

Changes in thin sections
(microprobe)

	0 mon	1 mon	2 mon
Ny-Mst	no photo		
Al-Mst	no photo		

No significant change after 1, 2 months

Changes of mudstones

- No visible change during the experiments, except for the colour change during storage.

Alteration of mudstone

- No visible change on the surface, nor internal change. No alteration effect so far.

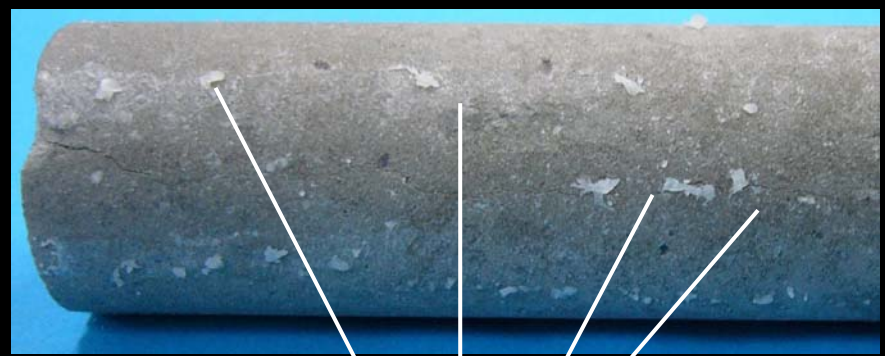
Results of casing cements surface changes

G-cement (0 month)

CO_2cement (0 month)

After 1 month

Turn to brown



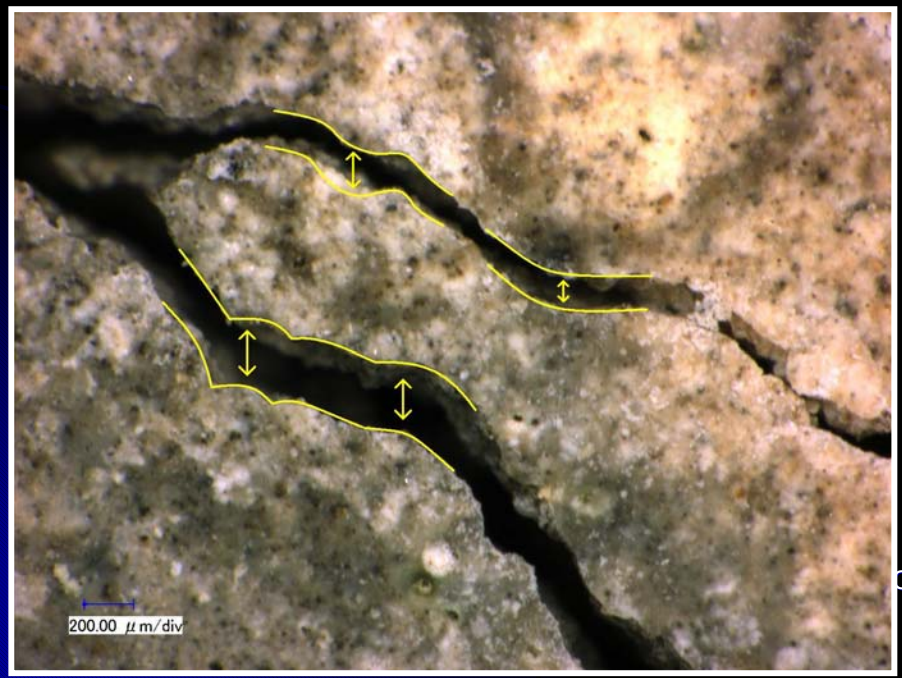
calcite crystals

Surface observations after 1 month exposure

Fractures in both specimens…

Class-G cement

CO_2 stop cement

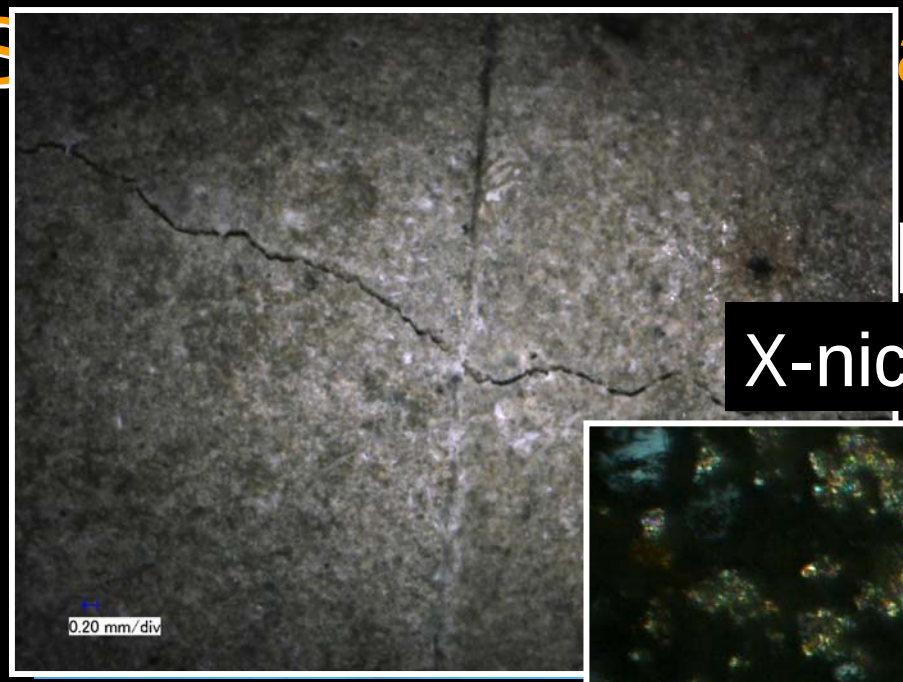


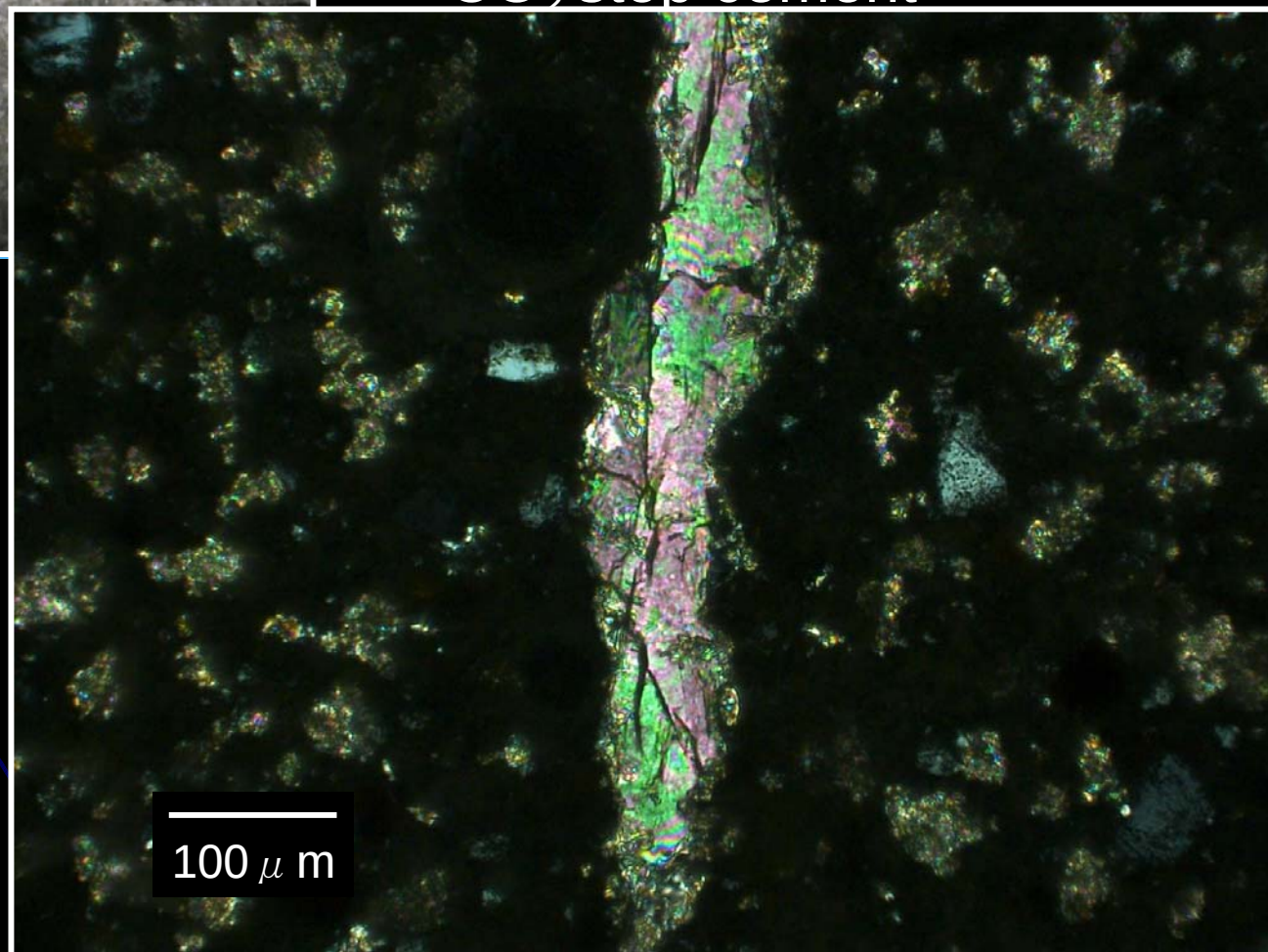
Pressure release caused expansion of CO_2 volume that broke the samples…

S after 1 month exposure

pecimens…

X-nichol image at the connection



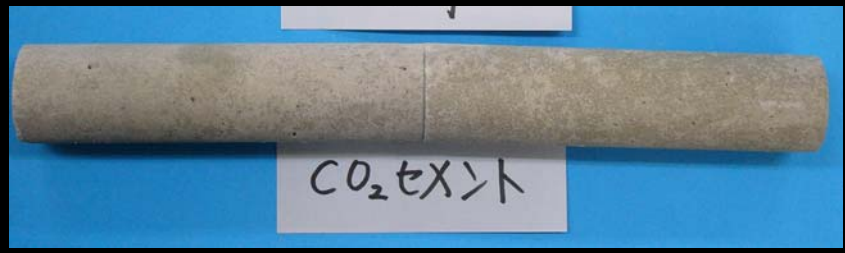


Surface observations

Class-G cement

CO_2 stop cement

after 2 months



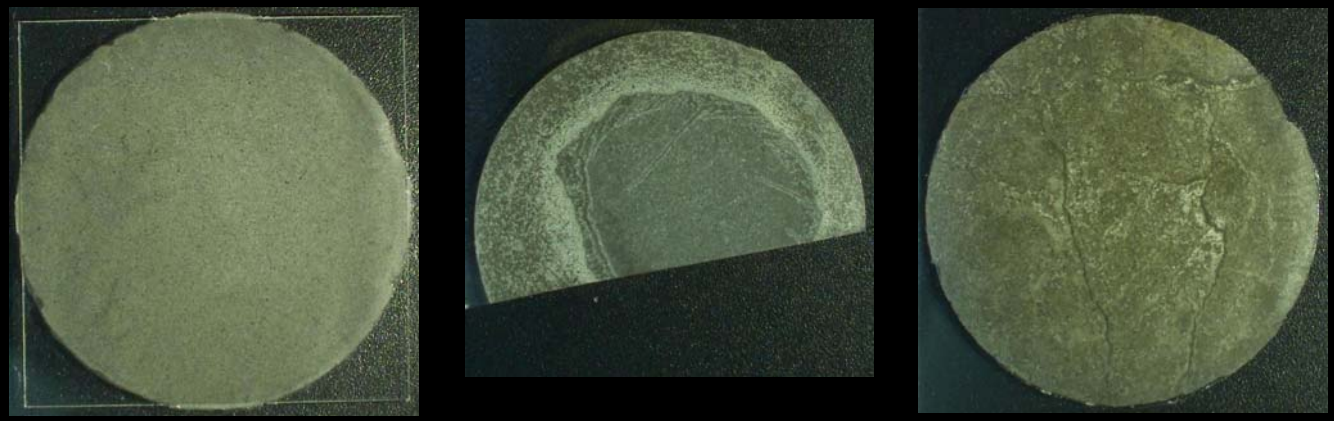
after 3 months

no apparent change

Changes on thin sections (microprobe)

0 month | 1 month | 2 months

G-cement

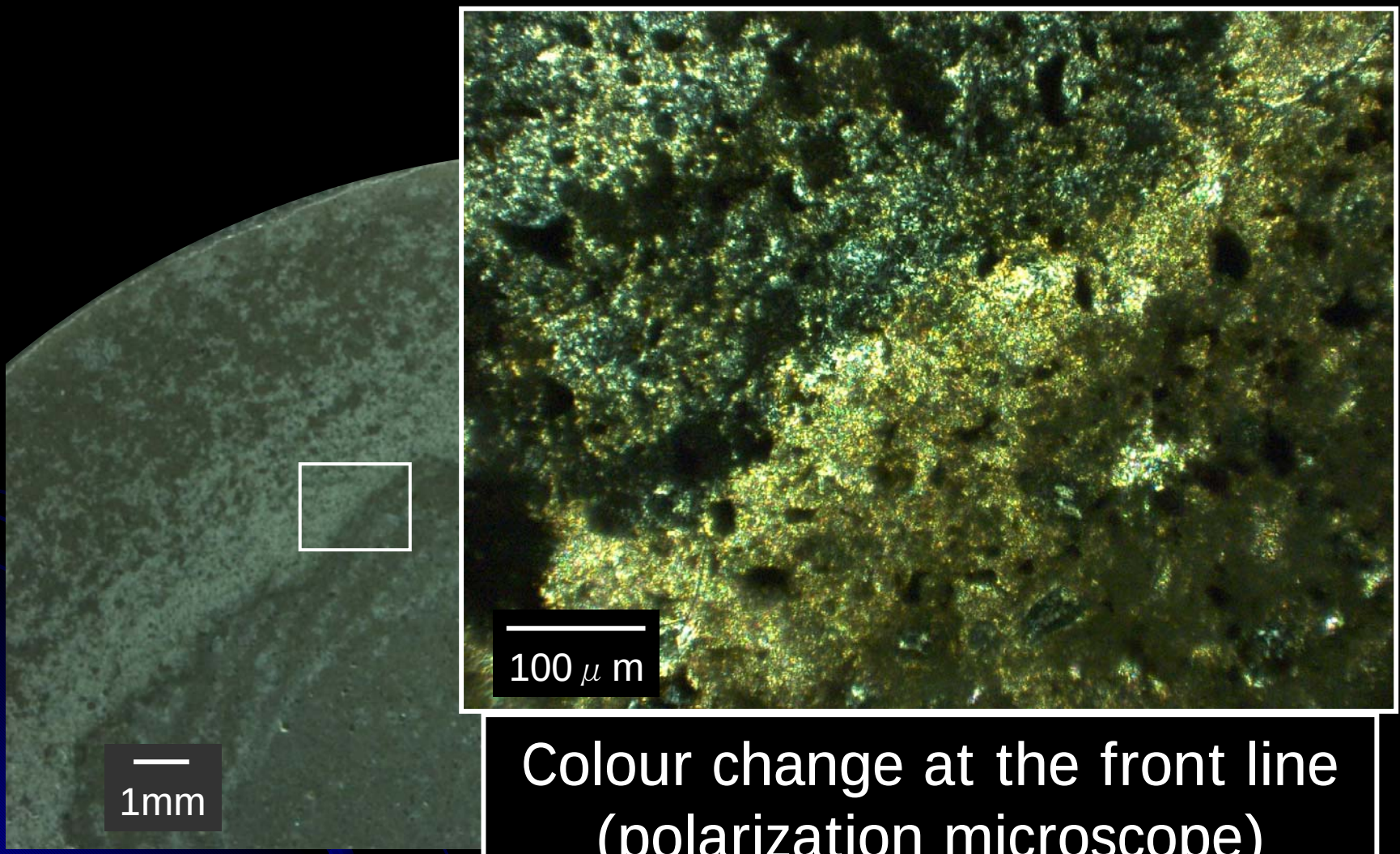


⇒ visible alteration from surface

CO_2cement

⇒ no such visible change

The front line (thin section)

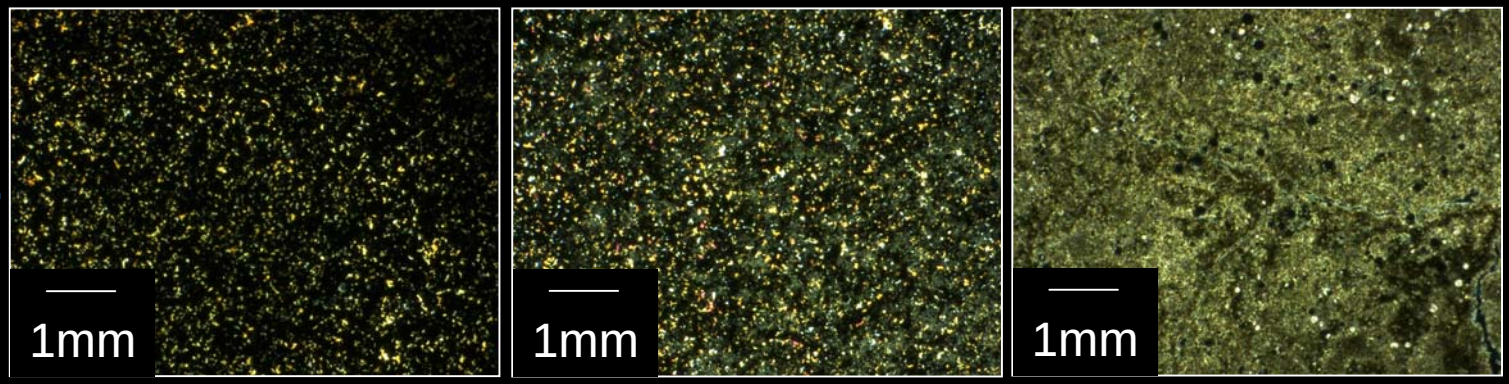


Colour change at the front line (polarization microscope)

Changes in the matrix (microscope)

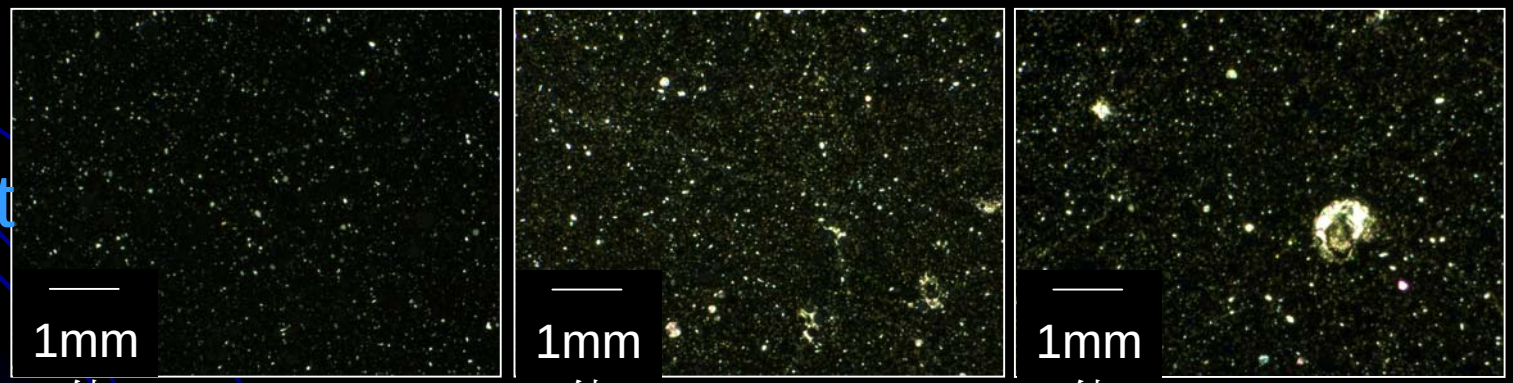
0 month | 1 month | 2 months

G-cement



⇒ gradual change of colour (crystal formation)

CO_2cement



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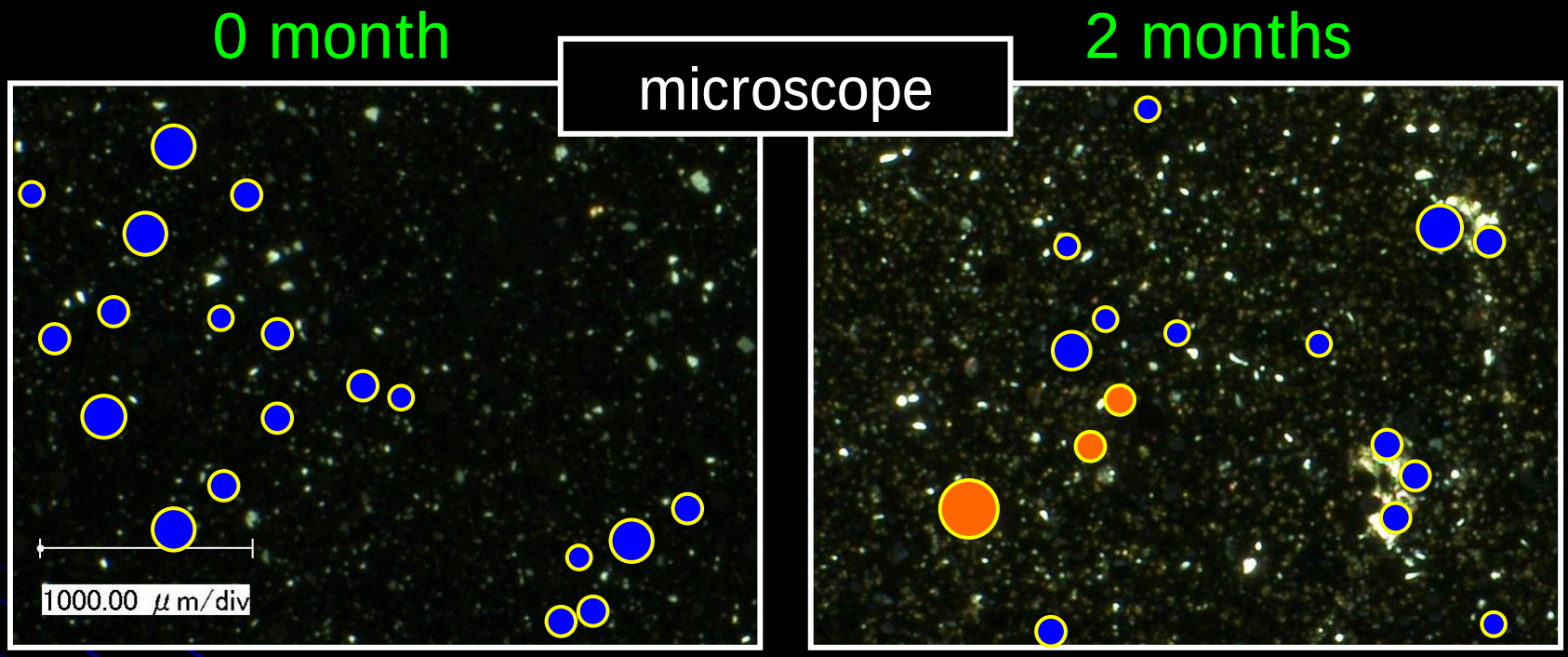
⇒ no such visible change, but…

Filling of pores (CO_2cement)



Some of the voids filled by calcite crystallization

Summary of observations

- G-cement shows significant changes; crystallization in the matrix, front-line formation etc...
- CO_2 cement shows minor changes; filled large pores and large crystals on the surface.

Porosity and permeability change

Class-G cement

	Before	1 month
Porosity (%)	43.7	44.0
Permeability (md)	1.08	0.53

Porosity stable

Permeability dropped

CO_2 stop cement

	Before	1 month
Porosity (%)	45.3	44.3
Permeability (md)	1.08	0.92

Porosity slightly decreased

Permeability decreased

Porosity and permeability measurements

- Pore spaces of both specimens are filled by calcite crystals, thus porosity should decrease.
- Porosity unchanged in G-cem, suggesting erosion compensated the crystallization.
- Permeability decrease in G-cem, less decrease in CO_2-cem.

Uniaxial compressive strength and tensile strength

	Class-G cement		CO_2 stop cement	
	Before	1 month	Before	1 month
S_c （MPa）	27.6	-	10.5	**17.3**
S_t （MPa）	3.3	**2.6**	1.5	**2.6**

- Sc: Uniaxial compressive strength

St: Tensile strength obtained by Brazilian test

G-cement weakening, CO_2-cem strengthen.

Conclusions

- Mudstones are strong enough for exposure of supercritical CO_2 for (at least) a few month.
- G-class cement is significantly altered by CO_2 exposure and weakened.
- CO_2 cement is slightly affected and even geo-mechanically stronger against alteration.

On going research

- Experiments with wet-super critical CO2
- Experiments with CO2-saturated water
- Geo-mechanical investigations
- Fracturing and crystallization
- Velocity measurements

Acknowledgements

- NEDO (New Energy Development Organization, Japan) for research funding

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